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G01S 1/24

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U1S S1820 S2147

(56) Documents cited
GB 2222922 A GB 2013062 A US 4555707 A

(58) Field of search
UK CL (Edition K) H4D DPDA DPDD DPDX
INT CL[5] G01S
On-line databases: WPI

(54) Vehicle location determining system

(57) The location of a vehicle or person, G5 is determined by measuring the differences in time of arrival between pairs of line or frame synchronising pulses received from 3 different TV signal transmitters S_1–S_3. The measurements are corrected for relative system time delays or signal synchronising alterations that may occur between pairs of relevant TV transmitter sites by using similar timing differences measured at a suitable known location G4 which is in radio contact with the vehicle. The intersection of the loci of the deduced distances from the transmitter sites establishes the mobile location to a reasonable degree of accuracy. The location is either presented as a set of positional co-ordinates or can be superimposed on an electronic map display.

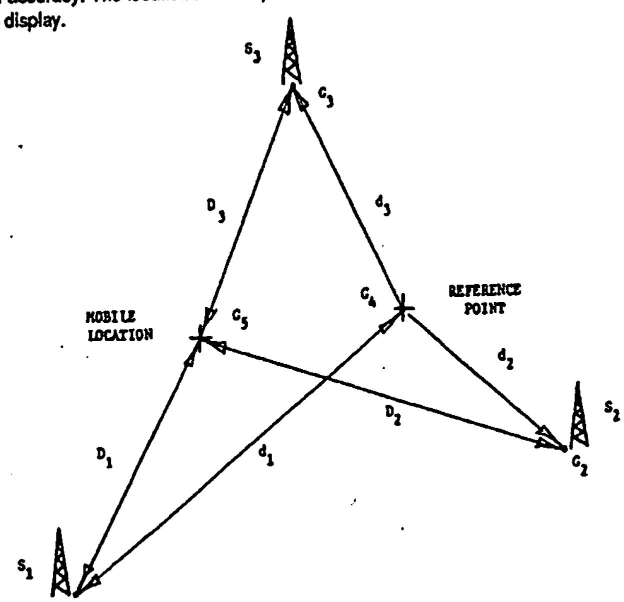

FIGURE 1

PLAN OF TV TRANSMITTER SITES & MEASUREMENT POINTS

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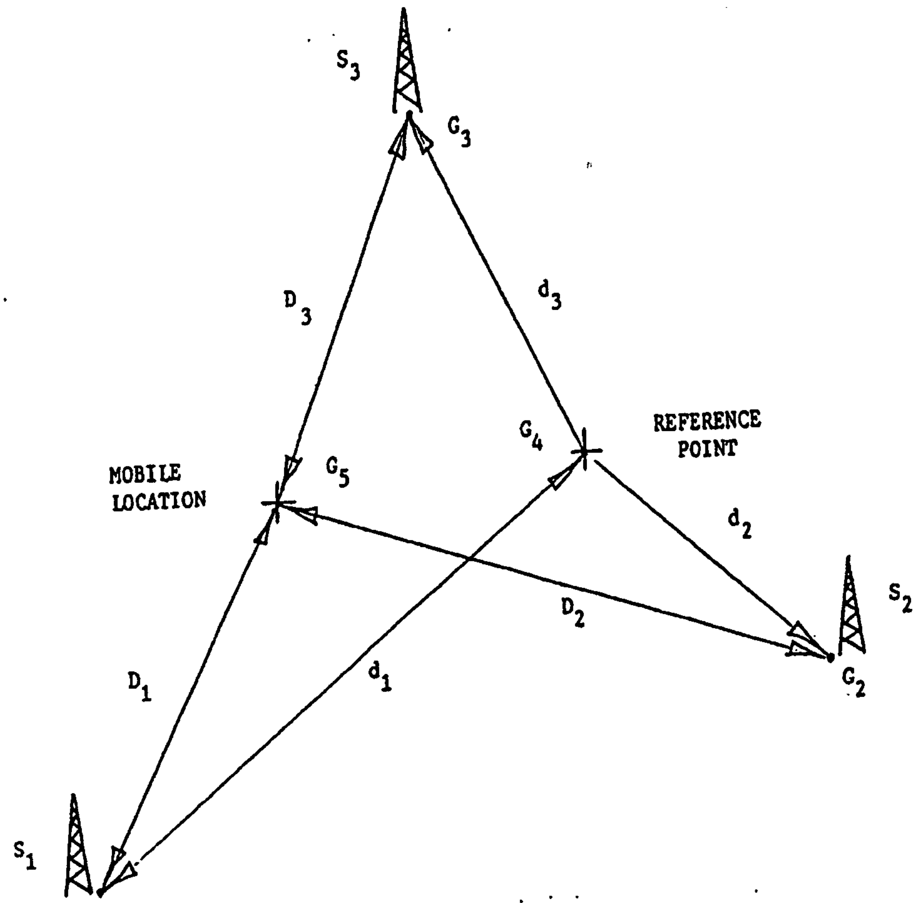
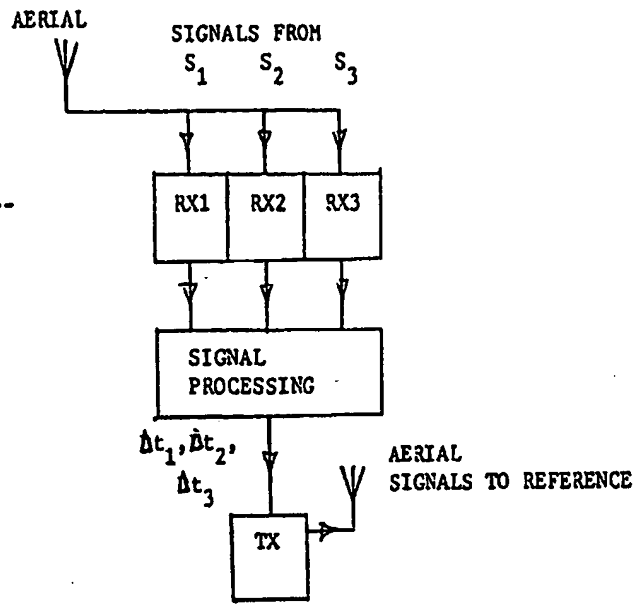


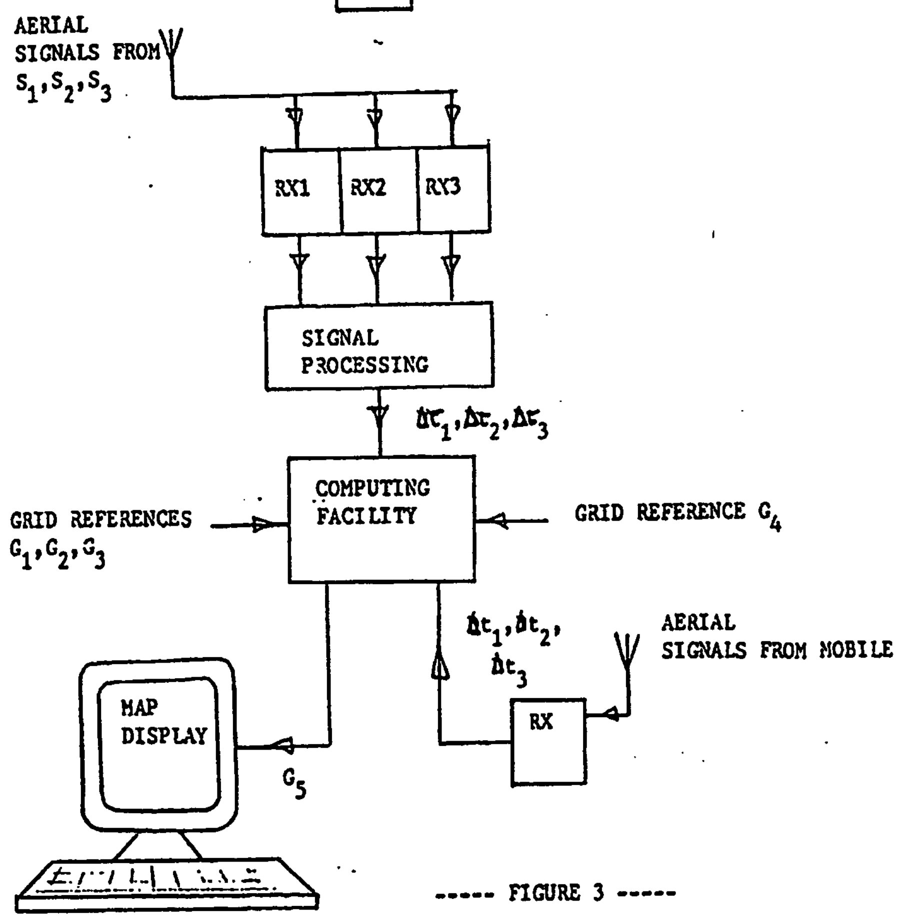
FIGURE 1

PLAN OF TV TRANSMITTER SITES & MEASUREMENT POINTS



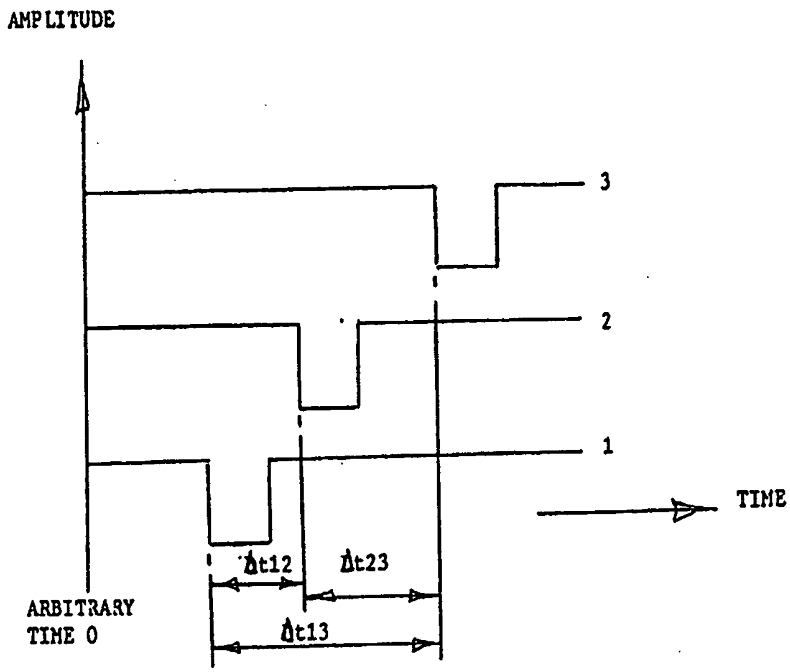
----- FIGURE 2 -----

MOBILE SYSTEM



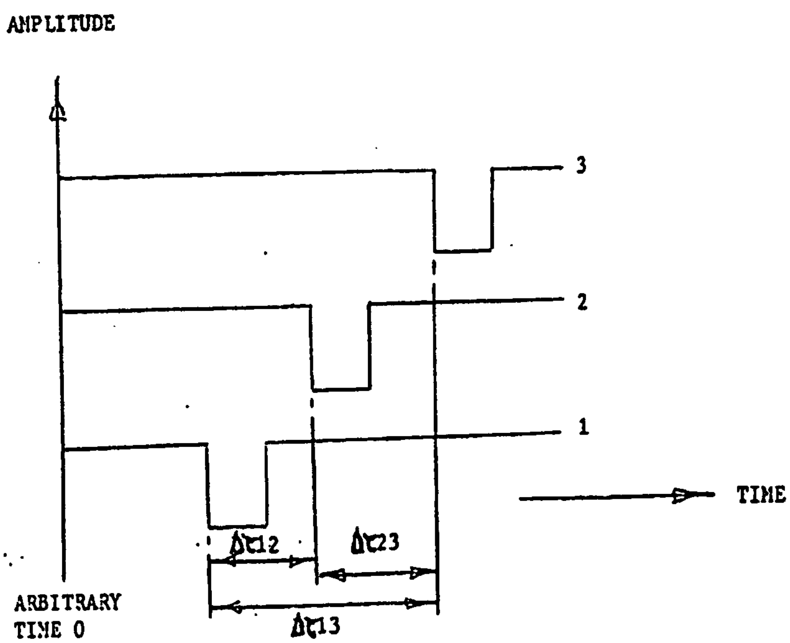
----- FIGURE 3 -----

REFERENCE SYSTEM



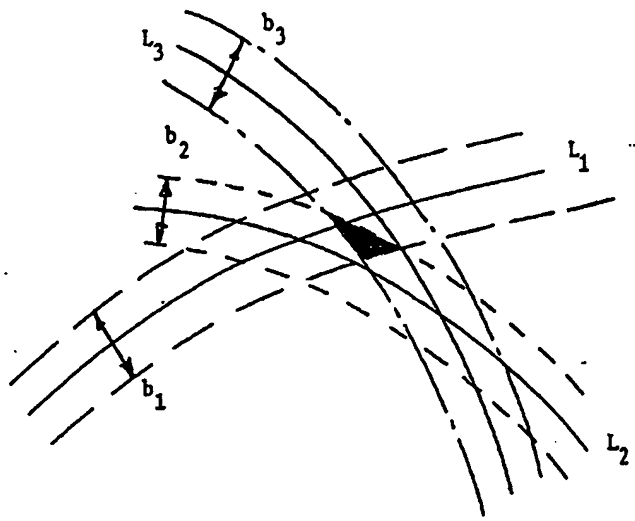
----- FIGURE 4 -----

TIMING SIGNALS AT MOBILE



----- FIGURE 5 -----

TIMING SIGNALS AT REFERENCE



----- FIGURE 6 -----

AREA OF UNCERTAINTY OF LOCATION

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VEHICLE LOCATOR SYSTEM

THIS INVENTION RELATES TO AN AN AUTOMATIC ELECTRONICALLY BASED METHOD OF LOCATING VEHICLES AND OR INDIVIDUALS BY THE USE OF TV SIGNALS.

THERE IS A CONSTANT NEED TO IDENTIFY THE POSITION OF VEHICLES AND/OR INDIVIDUALS IN THE COURSE OF THEIR DAILY DEPLOYMENT. THIS IS PARTICULARLY THE CASE FOR THE EMERGENCY SERVICES, MANY GOVERNMENT AND LOCAL GOVERNMENT AGENCIES AND DEPARTMENTS AND ALSO A GREAT VARIETY OF SERVICE RELATED BUSINESSES AND ORGANISATIONS. SOME OF THE METHODS USED TO ACHEIVE THE LOCATION OF MOVING VEHICLES AND OR PERSONNEL REQUIRE EXPENSIVE AND EXTENSIVE INFRA STRUCTURE TO BE ESTABLISHED AND MAINTAINED WHICH MAKES THE COST JUSTIFICATION UNREASONABLE FOR MANY APPLICATIONS. HENCE THERE IS A LATENT DEMAND FOR AN INEXPENSIVE, RELIABLE, REPEATABLE AND ACCURATE METHOD OF MOBILE VEHICLE/PERSONNEL LOCATION. THE REQUIREMENT IS FOR A SYSTEM THAT WILL REGULARLY UPDATE THE POSITION CO-ORDINATES AND HENCE MAP THE POSITION OF VEHICLES/PERSONNEL TO PERMIT EITHER THE SUBJECT TO IDENTIFY WHERE THEY ARE OR FOR A CONTROL POINT TO BE ABLE TO REMOTELY MONITOR AND TRACK THEIR MOVEMENTS. SUCH A SYSTEM WILL HAVE GREATER APPEAL IF IT CAN BE WIDE AREA AND CAN OPERATE WITHOUT ON-GOING DEPENDANCE ON HUMAN INVOLVEMENT FOR DATA AND INFORMATION INPUT.

PRESENT INVENTION COMPRISES A SYSTEM WHICH PROVIDES THE POSITION CO-ORDINATES AND HENCE MAP REFERENCE OF A SUBJECT OVER A WIDE AREA AND WITHOUT THE NECESSITY FOR AN ON-GOING DEPENDENCE ON HUMAN INPUT. THE SYSTEM CONSISTS OF TV SIGNAL RECEIVERS LOCATED AT THE MOBILE POINT AND AT A SUITABLE REFERENCE POINT WHICH USE LOCALLY TRANSMTTED TV SIGNALS TO GENERATE TIME DIFFERENCES WHICH CAN THEN BE USED TO DETERMINE THE POSITION OF THE MOBILE. THE FRAME AND LINE SYNCHRONISING PULSES FROM OVERLAPPING TV SIGNAL TRANSMITTERS HAVE SLOW ENOUGH REPITITION RATES AND FAST ENOUGH PULSE RISE TIMES RESPECTIVELY TO PERMIT UNAMBIGUOUS AND SUFFICIENTLY ACCURATE TIME INTERVALS TO BE MEASURED BETWEEN THE SIGNALS RECEIVED FROM THE DIFFERENT TV SIGNAL TRANSMITTERS. IF 3 SEPARATE TRANSMITTER SIGNALS ARE THUS PROCESSED THEN THE 3 TIMING DIFFERENCES MEASURED AT EACH OF THE MOBILE AND REFERENCE POINTS REQUIRE TO BE MADE AVAILABLE AT A SINGLE POINT TO DETERMINE THE SUBJECTS POSITION. SINCE THERE ARE MANY AREAS IN THE UK WHERE 3 SEPARATE TV TRANSMITTERS CAN BE SIMULTANEOUSLY RECEIVED AT THE SAME LOCATION THE SYSTEM HAS WIDE AREA APPLICATION. THIS IS DONE IN THE FOLLOWING MANNER:

1. THE POSITION CO-ORDINATES OF THE TV TRANSMITTER SITES AND THE REFERENCE POINT ARE ESTABLISHED AND USED TO CALCULATE THE DISTANCE BETWEEN EACH TRANSMITTER SITE AND THE REFERENCE POINT.

2. SINCE THE SPEED OF TRAVEL OF ELECTROMAGNETIC WAVE PROPOGATION IN FREE SPACE IS KNOWN THE CALCULATED DISTANCES BETWEEN THE TRANSMITTERS AND THE REFERENCE POINT ARE THEN TRANSFERRED INTO EQUIVALENT TIMES FOR THE TRANSIT OF THE SIGNALS FROM THE TRANSMITTERS TO THE REFERENCE POINT.

3. USING AN ELECTRONIC TIMING CIRCUIT THE TIME DIFFERENCES OF RECEIVING THE FRAME AND/OR LINE SYNCHRONISING PULSES FROM EACH PAIR OF TRANSMITTERS IS MEASURED AT THE REFERENCE POINT.

4. THE DIFFERENCES BETWEEN THE RESPECTIVE VALUES OF CALCULATED TRANSMIT TIMES FROM 2 ABOVE ARE SUBTRACTED FROM THE MEASURED TIMING DIFFERENCES OBTAINED BY 3 ABOVE. THIS ESTABLISHES A TIMING CORRECTION FACTOR FOR EACH PAIR OF TRANSMITTER SIGNALS WHICH ALLOWS FOR DIFFERENCES IN RELATIVE SYSTEM DELAYS AT EACH TRANSMITTER PAIR OR SYNCHRONISING ALTERATIONS THAT MAY OCCUR BETWEEN THEM.

5. USING AN ELECTRONIC TIMING CIRCUIT THE TIME DIFFERENCES OF RECEIVING THE FRAME AND/OR LINE SYNCHRONISING PULSES FROM EACH PAIR OF TRANSMITTERS ARE MEASURED AT THE MOBILE VEHICLE/PERSONNEL POINT.

6. THE TIMING CORRECTION FACTOR AS PER 4 ABOVE AND THE TIMING DIFFERENCES AS PER 5 ABOVE ARE MADE AVAILABLE FOR FURTHER PROCESSING AT A COMMON POINT, WHICH IS MOST LIKELY THE REFERENCE POINT, BY THE USE OF A PRIVATE MOBILE RADIO (PMR) LINK OR BY SOME OTHER MEANS OF COMMUNICATION BETWEEN THE MOBILE AND THE REFERENCE POINTS.

7. THE RESPECTIVE TIMING CORRECTION FACTORS AS ESTABLISHED BY 4 ABOVE ARE APPLIED TO THE TIME DIFFERENCE VALUES OBTAINED BY 5 ABOVE.

8. THE RESULTANT TIME DIFFERENCES FROM 7 ABOVE ARE THEN TRANSORMED INTO PHYSICAL DISTANCES USING AS A CONVERSION FACTOR THE SPEED OF ELECTROMAGNETIC RADIATION PROPOGATION IN FREE SPACE WHICH IS KNOWN.

9. BY PROCESSING SIGNALS FROM 3 TRANSMITTERS AS PER THE STEPS ABOVE THERE ARE NOW 3 VALUES KNOWN FOR THE RELATIVE DISTANCES FROM THE MOBILE POINT TO EACH OF THE TRANSMITTER LOCATIONS. EITHER BY CALCULATION OR BY THE USE OF LOOK-UP TABLES THESE 3 VALUES GIVE THE MOBILE POSITION WITH RESPECT TO THE TRANSMITTER LOCATIONS WHICH ARE FIXED AND KNOWN. HENCE THE LOCATION OF THE MOBILE IS ESTABLISHED.

IT SHOULD BE NOTED THAT IF LOSS OF SIGNAL(S) OCCURS AT THE REFERENCE OR MOBILE POINT THEN THE ON GOING DETERMINATION OF THE MOBILE LOCATION CANNOT PROCEED. HOWEVER, AS SOON AS THE SIGNAL RECEPTION IS RETURNED THE FULL ACCURACY OF THE SYSTEM IS ONCE AGAIN AVAILABLE, I.E. THE MEASUREMENT SYSTEM IS NOT DEPENDANT ON EITHER KNOWING THE CO-ORDINATES OF THE STARTING POSITION OF THE MOBILE OR HAVING TO MAINTAIN CONTINUOS RECEPTION OF THE TV SIGNALS THEREAFTER. A SPECIFIC EMOBODIMENT OF THE INVENTION WILL NOW BE DISCRIBED BY WAY OF AN EXAMPLE WITH REFERENCE TO THE ACCOMPANYING FIGURES AND DRAWINGS:

FIGURE 1 SHOWS A SCHEMATIC PLAN VIEW OF 3 TV TRANSMITTER SITES. THE LOCATION OF A MOBILE SUBJECT AND A FIXED REFERENCE POINT.

FIGURE 2 SHOWS THE ELEMENTS OF A SIGNAL RECEIVER AND PROCESSOR SYSTEM FOR USE BY A MOBILE SUBJECT.

FIGURE 3. SHOWS THE ELEMENTS OF A SIGNAL RECEIVER AND PROCESSOR SYSTEM FOR USE AT A FIXED REFERENCE POINT.

FIGURE 4 SHOWS THE SIGNAL TIMING DIFFERENCES MEASURED AT A MOBILE VEHICLE/PERSON.

FIGURE 5 SHOWS THE SIGNAL TIMING DIFFERENCES MEASURED AT A FIXED REFERENCE POINT.

FIGURE 6 SHOWS A TYPICAL AREA OF UNCERTAINTY OF POSITION ESTABLISHMENT FOR A MOBILE VEHICLE/PERSON.

WITH REFERENCE TO THE ABOVE FIGURES THE VEHICLE LOCATION SYSTEM OPERATES AS FOLLOWS.

THERE ARE 3 TV TRANSMITTER SITES S1, S2 AND S3 WITH KNOWN GRID REFERENCES OF G1,G2 AND G3 RESPECTIVELY. A FIXED REFERENCE POINT WITHIN THE RECEPTION AREA AT THE TRANSMITTERS S1, S2 AND S3 HAS A KNOWN GRID REFERENCE OF G4 AND IS LOCATED A DISTANCE d1, d2 AND d3 FROM S1, S2 AND S3 RESPECTIVELY. A MOBILE VEHICLE/PERSON IS WITHIN THE RECEPTION AREA OF THE TRANSMITTERS AT S1, S2 AND S3 AND HAS AN UNKNOWN GRID REFERENCE G5. THE MOBILE POINT IS LOCATED AT A DISTANCE OF D1, D2 AND D3 FROM TRANSMITTER SITES S1. S2 AND S3 RESPECTIVELY.

WITH REFERENCE TO FIGURE 2 THE TV SIGNALS TRANSMITTED FROM THE SITES S1, S2 AND S3 ARE RECEIVED BY TUNED RECEIVERS RX1, RX2 AND RX3 RESPECTIVELY LOCATED AT THE MOBILE POINT. THE LINE SYNCHRONISING SIGNALS RECEIVED FROM EACH OF THE TRANSMITTERS ARE COMPARED ON A TIME BASE AS SHOWN IN FIGURE 4. THE TIME DIFFERENCES OF THE SIGNALS FROM TRANSMITTERS 1 & 2, 2 & 3 AND 1 & 3 ARE ELECTRONICALLY TIMED AS $\Delta t12$, $\Delta t23$ amd $\Delta t13$ RESPECTIVELY.

WITH REFERENCE TO FIGURE 3 THE TV SIGNALS TRANSMITTED FROM THE SITES S1, S2 AND S3 ARE RECEIVED BY TUNED RECEIVERS RX1, RX2 AND RX3 RESPECTIVELY LOCATED AT THE REFERENCE POINT. THE LINE SYNCHRONISING SIGNALS RECEIVED FROM EACH OF THE TRANSMITTERS ARE COMPARED ON A TIME BASE AS SHOWN IN FIGURE 5. THE TIME DIFFERENCES OF THE SIGNALS FROM TRANSMITTERS 1 & 2, 2 & 3 AND 1 & 3 ARE ELECTRONICALLY TIMED AS $\Delta\tau_{12}$, $\Delta\tau_{23}$ AND $\Delta\tau_{13}$ RESPECTIVELY.

WITH FURTHER REFERENCE TO FIGURE 3 A COMPUTING FACILITY IS AVAILABLE AT THE REFERENCE POINT WHICH HAS THE FOLLOWING DATA AS INPUT.

1. THE VALUES OF $\Delta\tau_{12}$, $\Delta\tau_{23}$ AND $\Delta\tau_{13}$.

2. THE VALUES OF Δt_{12}, Δt_{23} AND Δt_{13} WHICH ARE OBTAINED AT THE REFERENCE POINT FROM THE MOBILE LOCATION ACROSS A PRIVATE MOBILE RADIO (PMR) LINK.

3. GRID REFERENCES G1, G2, G3 AND G4.

THE COMPUTING FACILITY USES THE GRID REFERENCES G1, G2, G3 AND G4 TO CALCULATE DIFFERENCES IN DISTANCE BETWEEN THE REFERENCE POINT AND EACH PAIR OF TRANSMITTERS SHOWN IN FIGURE 1. J.E. (d1 - d2), (d2 - d3) AND (d1 - d3). IF $\Delta T1$, $\Delta T2$ AND $\Delta T3$ ARE THE TIMES FOR ELECTROMAGNETIC RADIATION IN FREE SPACE TO TRAVEL THE DISTANCES (d1 - d2)), (d2 - d3) AND (d1 - d3) RESPECTIVELY THEN THE MOBILE VEHICLE/PERSON IS A DISTANCE (D1 - D2), (D2 - D3) AND (D1 - D3) RESPECTIVELY NEARER TO S1, S2 AND S3 RESPECTIVELY THAN S2. S3 AND S3 RESPECTIVELY. FURTHERMORE THESE 3 DISTANCES CAN BE CALCULATED BY THE FOLLOWING RELATIONSHIPS:

$$(D1 - D2) = K.\Delta T12 \quad - \quad (1)$$

$$(D2 - D3) = K.\Delta T23 \quad - \quad (2)$$

$$(D1 - D3) = K.\Delta T13 \quad - \quad (3)$$

WHERE K = SPEED OF ELECTROMAGNETIC RADIATION IN FREE SPACE

AND

$$\Delta T12 = \Delta t12 - (\Delta \tau 12 - \Delta T1)$$

$$\Delta T23 = \Delta t23 - (\Delta \tau 23 - \Delta T2)$$

$$\Delta T13 = \Delta t13 - (\Delta \tau 13 - \Delta T3)$$

FIGURE 6 SHOWS THE LOCUS PLOTS L1, L2 AND L3 WHICH ARE LINES OF CONSTANT VALUES OF THE DISTANCES (D1 - D2), (D2 - D3) AND (D1 - D3) RESPECTIVELY. GIVEN THAT THERE ARE FINITE RESOLUTIONS OF MEASUREMENT OF THE Δt AND $\Delta \tau$ VALUES THEN THE LOCUS PLOTS L1, L2 AND L3 MAY NOT BE COINCIDENTAL.

HOWEVER IF THE LOCUS PLOTS L1, L2 AND L3 ARE KNOWN TO BE ACCURATE TO WITHIN THE RANGE OF b1, b2 AND b3 RESPECTIVELY THEN THE POSITION OF THE MOBILE VEHICLE/PERSON MUST BE WITHIN THE SHADED AREA WHICH IS THE AREA WITHIN WHICH ALL POINTS ARE WITHIN THE CALCULATED LEVEL OF ACCURACY OF EACH INDIVIDUAL LOCUS PLOT I.E. $L1 \pm \frac{b1}{2}$, $L2 \pm \frac{b2}{2}$ AND $L3 \pm \frac{b3}{2}$. BY THE METHOD OF LEAST SQUARES APPROXIMATION OR BY AN ALTERNATIVE ACCEPTED MEANS OF ARITHMETIC AVERAGING THE POSITION OF THE MOBILE VEHICLE/PERSON WITH RESPECT TO S1, S2 AND S3 IS ESTABLISHED. SINCE THE POSITION CO-ORDINATES OF S1, S2 AND S3 ARE KNOWN THEN THE ASSOCIATE POSITION CO-ORDINATES OF THE MOBILE POINT CAN BE CALCULATED. THESE CO-ORDINATES CAN THEN BE USED TO SHOW ON A VISUAL DISPLAY UNIT A MAP POSITION AS SHOWN IN FIGURE 3.

IF REQUIRED THE MOBILE REFERENCE SYSTEMS DESCRIBED IN FIGURES 2 AND 3 CAN BE MODIFIED TO CARRY OUT THE COMPTUTATIONAL OPERATIONS AT THE MOBILE (OR SOME OTHER LOCATION) RATHER THAN THE REFERENCE POINT. IN WHICH CASE VALUES FOR $\Delta\tau_{12}$, $\Delta\tau_{23}$ AND $\Delta\tau_{13}$ ARE TRANSMITTED FROM THE REFERENCE POINT TO THE MOBILE POINT (OR SOME OTHER LOCATION INSTEAD OF THE REVERSE AS SHOWN IN FIGURES 2 AND 3.

FURTHERMORE IF SO ARRANGED 2 RECEIVERS IN PLACE OF 3 CAN BE USED AT THE REFERENCE AND/OR MOBILE POINTS. THIS IS ACHEIVED BY FIRST MEASURING THE TIME DIFFERENCE BETWEEN SIGNALS 1 & 2 ON RECEIVERS RX1 & RX2 RESPECTIVELY RX2 IS THEN MADE TO OPERATE AS RX3. THE TIME DIFFERENCE BETWEEN SIGNALS 1 & 3 IS THEN MEASURED. RX1 IS THEN MADE TO OPERATE AS RX2 AND THE TIME DIFFERENCE BETWEEN SIGNALS 2 & 3 IS MEASURED. THESE SWITCHING OPERATIONS MAY BE CARRIED OUT MANUALLY OR ELECTRONICALLY.

DEPENDING ON THE POSITION OF THE CHOSEN REFERENCE POINT AND THE POSITION OF THE MOBILE THE PARTICULAR COMBINATION OF SITES S1, S2 AND S3 MAY REQUIRE TO BE CHANGED IN ORDER TO HAVE 3 TRANSMITTING SITES WHICH CAN BE RECEIVED AT REFERENCE AND MOBILE POINTS HAVING GRID REFERENCES G4 AND G5 RESPECTIVELY. THE OPERATION TO PERMIT TWO SETS OF RECEIVERS RX1, RX2 AND RX3 TO RECEIVE A DIFFERENT COMBINATION OF SITES MAY BE CARRIED OUT MANUALLY OR ELECTRONICALLY. IT SHOULD ALSO BE NOTED THAT THE FRAME SYNCHRONISING SIGNAL REPETITION RATE IS 25 TIMES/SECOND OR EVERY 40 mSECS WHICH AT THE SPEED OF ELECTROMAGNETIC RADIATION PROPOGATION IN FREE SPACE REPRESENTS A DISTANCE OF SOME 13.000 KILOMETRES. HENCE THERE IS NO AMBIGUITY AT THE REFERENCE AND MOBILE MEASUREMENT POINTS AS TO WHICH FRAME PERIOD IS BEING USED TO DEDUCE THE MOBILE POSITION.

HOWEVER SINCE EACH NEW LINE SYNCHRONISING PULSE OCCURS EVERY $\frac{40}{625}$ mSECS THIS CORRESPONDS TO A DISTANCE OF FREE SPACE ELECTROMAGNETIC PROPAGATION OF APPROXIMATELY 20 KILOMETRES HENCE IT NEEDS TO BE NOTED WHICH LINE SYNCHRONISING PULSE IS BEING USED FOR THE TIMING OPERATIONS AT THE REFERENCE AND MOBILE MEASUREMENT POINTS SINCE THE AREA OF OPERATIONAL COVERAGE OF A PARTICULAR COMBINATION OF TV BASE SITES S1, S2 AND S3 COULD OFTEN BE GREATER THAN APPROXIMATELY 20 KILOMETRES SQUARE.

REGARDING TOPOGRAPHICAL CHANGES, IT IS RECOGNISED THAT THE SITES S1, S2 AND S3 WILL NORMALLY BE LOCATED AT HEIGHTS CONSIDERABLY HIGHER ABOVE MEAN SEA LEVEL THAN MOST IF NOT ALL OF THE EFFECTIVE OPERATIONAL AREA OF THE MOBILE AND THE LOCATION OF THE REFERENCE POINT, EITHER BY CALCULATION OR BY USING SUITABLE MODIFICATIONS OF THE LOOK-UP TABLES LOCATED IN THE COMPUTING FACILITY THESE HEIGHT DIFFERENCES CAN BE TAKEN INTO CONSIDERATION IN ORDER TO MINIMISE ERRORS INTRODUCED BY ALL POINTS NOT BEING AT THE SAME HEIGHT ABOVE MEAN SEA LEVEL.

FINALLY, REGARDING THE ACCURACY OF MEASUREMENT IT IS RECOGNISED THAT THIS IS LARGELY LIMITED BY THE RISE TIME OF THE LINE SYNCHRIONISING PULSE AND HENCE ITS ABILITY TO ACT AS A REPEATABLE SWITCH FOR TIMING PURPOSES. TYPICALLY THIS RISE TIME IS NO MORE THAN 0.2 μSEC WHICH REPRESENTS A DISTANCE OF APPROXIMATELY 65 M FOR THE PROPOGATION OF ELECTROMAGNETIC RADIATION IN FREE SPACE HENCE ALLOWING FOR THIS RESOLUTION IN TIMING MEASUREMENTS AND ALSO THE ERRORS INTRODUCED FROM THE COMPUTATIONAL STEPS TO BE MADE, THE OVERALL ACCURACY OF THE SYSTEM GIVES A POSITIONAL REFERENCE FOR THE MOBILE POINT TO WITHIN AN ABSOLUTE ACCURACY OF A FEW HUNDRED METRES, AT WORST THE AREA OF UNCERTAINTY OF THE MEASUREMENT AS DESCRIBED ABOVE COULD HOWEVER CONSIDERABLY IMPROVE ON THIS DEGREE OF ACCURACY.

CLAIMS

1. AN ELECTRONIC MEANS OF TV SIGNAL RECEPTION AND SIGNAL PROCESSING FROM 3 DIFFERENT TRANSMITTER SITES WHERE BY THE GRID REFERENCE OF THE LOCATION OF A VEHICLE OR PERSON WITHIN THE SIGNAL RECEPTION AREAS OF THESE SITES CAN BE CALCULATED OR DEDUCED TO A USEFUL LEVEL OF ACCURACY. THE TV LINE AND FRAME SYNCHRONISING PULSES HAVE SUITABLY FAST RISE TIMES AND SLOW REPITITION RATES RESPECTIVELY TO PERMIT THE GENERATION OF A SERIES OF UNAMBIGUOUS TIMING DIFFERENCES WHICH HAVE A SUFFICIENT DEGREE OF ACCURACY TO PERMIT RELATIVE DISTANCES TO BE CALCULATED BASED ON THE KNOWN SPEED OF ELECTROMAGNETIC WAVE PROPAGATION IN FREE SPACE.

2. A SYSTEM AS DESCRIBED IN CLAIM 1 WHICH USES A REFERENCE TV SIGNAL RECEIVING POINT WITH A KNOWN GRID REFERENCE IN ORDER TO ELIMINATE ANY RELATIVE SYSTEM TIME DELAYS OR SIGNAL SYNCHRONISING ALTERATIONS THAT MAY OCCUR BETWEEN PAIRS OF RELEVANT TV TRANSMITTER SITES.

3. A SYSTEM AS DESCRIBED IN CLAIMS 1 AND 2 WHERE THERE IS A COMPUTING FACILITY LOCATED EITHER AT THE MOBILE OR REFERENCE POINT OR AT SOME OTHER LOCATION WHICH IS USED TO AUTOMATICALLY CALCULATE OR DEDUCE THE GRID REFERENCE OF THE MOBILE LOCATION WHICH CAN THEN BE SHOWN ON AN ELECTRONICALLY GENERATED MAP DISPLAY ON A VISUAL DISPLAY UNIT OR USED IN SOME OTHER SUITABLE FORM OF PRESENTATION.

THIS CLAIM DEPENDS ON A SUITABLE COMMUNICATIONS LINK EXISTING BETWEEN THE MOBILE AND REFERENCE POINTS OR BETWEEN BOTH THESE POINTS AND SOME OTHER 3RD POINT.

4. THE POSITIONAL ACCURACY OBTAINED BY THE SYSTEM IN CLAIMS 1.2 AND 3 CAN BE IMPROVED BY PROCESSING ALL 3 RATHER THAN 2 PAIRS OF SIGNALS FROM THE 3 RELEVANT TV TRANSMITTER SITES.

5. THE TV SIGNAL RECEPTION CIRCUITRY USED BY THE SYSTEM DESCRIBED IN CLAIMS 1 AND 2 MAY BE SIMPLIFIED BY USING 2 SWITCHABLE RECEIVERS RATHER THAN 3 PRE-TUNED RECEIVERS AT BOTH OR EITHER OF THE REFERENCE AND MOBILE MEASUREMENT POINTS.

6. INTERMITTANT RECEPTION OF TV SIGNALS RECEIVED IN THE SYSTEM DESCRIBED IN CLAIMS 1, 2 AND 3 ABOVE WILL NOT IMPAIR THE ACCURACY OF THE DEDUCED MOBILE LOCATION DURING PERIODS WHEN THE SIGNALS ARE NOT ALL RECEIVED. THIS ALSO MEANS THAT THE STARTING LOCATION OF THE MOBILE IS IRRELEVANT TO THE OPERATION OF THE SYSTEM.

7. THE ACCURACY OF THE CALCULATED OR DEDUCED LOCATION OF THE MOBILE POINT AS PER CLAIMS 1,2 AND 3 CAN BE IMPROVED ON BY MAKING APPROPRIATE CORRECTIONS FOR THE RELATIVE HEIGHTS OF THE TV SIGNAL TRANSMITTING AND RECEPTION POINTS.

8. THE SYSTEM DESCRIBED IN CLAIMS 1 AND 2 CAN GIVE VERY WIDE AREA COVERAGE OF MOBILE LOCATION BY SWITCHING THE TUNED RECEIVERS AT THE REFERENCE AND MOBILE POINTS TO RECEIVE SIGNALS FROM THE MOST SUITABLE SET OF 3 TV TRANSMITTERS AVAILABLE.

Amendments to the claims
have been filed as follows

1. A method of determining the location of a mobile body comprising receiving a television signal from three different transmitter sites, determining the difference in propagation time for signals from each pair of said three transmitter sites to arrive at said location by measuring the differences in the times of arrival at said location of frame and/or line synchronising pulses forming part of said television signal, and deriving the location of said mobile body therefrom.

2. A method as claimed in Claim 1, further including the step of correcting each of said measured time differences by a respective correction factor based upon the respective difference in propagation time for signals from each pair of said three transmitters to arrive at a known reference location.

3. A method as claimed in Claim 2, wherein a permanent receiving station is located at said reference location, said correction factors being periodically updated to take account of alterations in synchronism between the transmission of said signal from said transmitter sites.

4. A method as claimed in Claim 3, wherein said correction factors are derived by calculating the difference in propagation time for signals from each pair of said transmitter sites to arrive at said reference location, from the known distance between said reference location and each of said transmitter sites and the known speed of electromagnetic propagation, measuring the differences in the times of

arrival of said frame and/or line synchronising pulses at said reference location from each of said transmitter sites, and subtracting said calculated time differences from the respective measured time differences.

5. A method as claimed in Claim 3 or Claim 4, wherein the time differences measured at said mobile body are communicated by any suitable means to said permanent receiving station, the location of the mobile body being derived by computer means at said station.

6. A method as claimed in Claim 3 or Claim 4, wherein said time differences measured at said reference location or said correction factors are communicated by any suitable means to said mobile body, the location of the mobile body being derived by computer means carried by said mobile body.

7. A method as claimed in Claim 5 or Claim 6, wherein the location of said mobile body is expressed as a grid reference and/or displayed on suitable visual display means.

8. A method as claimed in any preceding Claim, wherein the relative heights of said transmitter site aerials are taken into account in the calculation of time differences and distances.

9. Apparatus for determining the location of a mobile body, comprising television signal receiver means adapted to receive a television signal from each of three transmitter sites, signal processing means for measuring the differences in the times of arrival between frame and/or line synchronising pulses forming

part of said television signal from each pair of said three transmitter sites, and computer means adapted to derive the location of said mobile body from said time differences.

10. Apparatus as claimed in Claim 9, wherein said computer means is further adapted to correct said time differences by the application of correction factors thereto.

11. Apparatus as claimed in Claim 10, wherein said signal receiver and signal processing means are carried by said mobile body, said apparatus further including second, similarly adapted signal receiver and signal processing means located at a known reference location and adapted to measure a second set of time differences at said reference location, said computer means being adapted to calculate said correction factors from said second set of time differences and from the known relative positions of said transmitter sites and said reference location.

12. Apparatus as claimed in Claim 11, wherein said computer means is located at said reference location, and wherein said mobile body also carries means for communicating said measured time differences from said mobile body to said reference location.

13. Apparatus as claimed in Claim 11, wherein said computer means is carried by said mobile body and means are located at said reference location for communicating said correction factors and/or said second set of time differences to said mobile body.

14. Apparatus as claimed in any one of Claims 9 to 13,

further including visual display means for displaying the location of said mobile body.

15. Apparatus as claimed in any one of Claims 9 to 14, wherein said signal receiver means includes one receiver for each of said transmitter sites.

16. Apparatus as claimed in any one of Claims 9 to 14, wherein said receiver means includes two receivers, at least one of which is adapted to receive said signal from any selected one of a plurality of transmitter sites.

17. Apparatus as claimed in any one of Claims 9 to 16, wherein said receiver means is adapted to selectively receive signals from the most appropriate three out of a larger plurality of transmitter sites.

18. A method of determining the location of a mobile body, substantially as hereinbefore described with reference to the accompanying drawings.

19. Apparatus for determining the location of a mobile body, substantially as hereinbefore described with reference to the accompanying drawings,

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number: 9106842.9

Relevant Technical fields

(i) UK Cl (Edition K) H4D(DPDA,DPDD,DPDX)

(ii) Int Cl (Edition 5) GOIS

Search Examiner

D J MOBBS

Databases (see over)

(i) UK Patent Office

(ii) Online Databases : WPI

Date of Search

06 JUNE 1991

Documents considered relevant following a search in respect of claims 1-8

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2222922 A (SPECTRONICS MICRO SYSTEMS)	1,3,4, 6,8
X	GB 2013062 A (WEISSER)	1-6,8
X	US 4555707 (CONNELLY)	1,3,4, 6,8

SF2(p)

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Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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